Answer Key

1.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

$$\frac{101.3 \text{ kPa} \times 1400\text{L}}{298 \text{ K}} = \frac{P_2 \times 10.0 \text{ L}}{263 \text{ K}}$$

$P_2 = 1.25 \times 10^4$ kPa = 12 500 kPa

2.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{1520 \text{ mm Hg}}{298 \text{ K}} = \frac{1900 \text{ mm Hg}}{T_2} = 373 \text{ K}$$

3. The diagram should show the balloon before and after sitting in the Sun. The gas molecules in the balloon before sitting in the Sun are closer together than the gas molecules in the balloon after sitting in the Sun. The diagram of the balloon after sitting in the Sun should show the gas molecules moving a faster rate. The gas molecules move faster and press against the walls with more force when heated, which causes the balloon to expand.
4. The carbon dioxide molecules in a pop can move faster and more forcefully when shaken. More dissolved carbon dioxide molecules come out of solution and into the gaseous state. This causes the pressure inside the can to build up. When the pop can is opened, the gas molecules move to a space that has less pressure to relieve the increased force inside the can. This causes the pop in the pop can to exit the can and spill over.
5. An aerosol can exploding in a fire shows a direct relationship between pressure and temperature. When the temperature increases, the gas molecules move faster and push against the walls of the can with more force. The volume of the can remains constant, until it explodes from the excessive pressure. This shows Gay-Lussac's law.
6.

$P_1 \text{ x } V_1 = P_2 \text{ x } V_2$

$1.5 \text{ atm x } 30 \text{ mL} = P_2 \text{ x } 100 \text{ mL}$

$P_2 = 0.45 \text{ atm}$

7.

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

$$\frac{45 \text{ L}}{V_2} = \frac{284 \text{ kPa}}{203 \text{ kPa}}$$

$V_2 = 32 \text{ L}$

8.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

$$\frac{250\text{ mL} \times 120\text{ kPa}}{297\text{ K}} = \frac{101.3\text{ kPa} \times V_2}{273\text{ K}}$$

$V_2 = 272$ mL

9.

$$V_m = \frac{V}{n}$$

$V = V_m \times n = 22.4$ L/mol $\times$ 5.05 mol = 113 L

10. $PV = nRT$

$$n = \frac{PV}{RT} = \frac{(95.0\text{ kPa})(10.0\text{ L})}{(8.314\frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}})(268)} = 0.426\text{ mol}$$

11.

$$P = \frac{nRT}{V} = \frac{6.7\text{ mol} \times 8.314\frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 303\text{ K}}{3.5\text{ L}} = 4.8 \times 10^2\text{ kPa}$$ = 482 kPa

12. Find molar mass of C_2H_4. Then use $n = m/M$ to solve for n. Use a mole ratio to find the number of moles of H_2O, using the number of moles of C_2H_4 and the balanced equation. Use $PV = nRT$ to find V.

Mass of C_2H_4 = (2 × 12.01 g/mol) + (4 × 1.01 g/mol) = 28.06 g/mol

$$n = \frac{m}{M} = \frac{15.0\text{ g}}{28.06\text{ g/mol}} = 0.535\text{ mol}$$

Mole ratio: $$\frac{1\text{ mol } C_2H_4}{2\text{ mol } H_2O} = \frac{0.535\text{ mol}}{x}$$

$x = 1.07$ mol

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{1.07\text{ mol} \times 8.314\frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 298\text{ K}}{100\text{ kPa}} = 26.5\text{ L}$$

13. Use $PV = nRT$ to find n. Use $n = m/M$ to find M.

$$n = \frac{PV}{RT} = \frac{122\text{ kPa} \times 0.750\text{ mol}}{8.314\frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 308\text{ K}} = 0.0357\text{ mol}$$

$$M = \frac{m}{n} = \frac{5.00\text{g}}{0.0357\text{ mol}} = 140\text{ g / mol}$$

14. Use $PV = nRT$ to find n. Use a mole ratio to convert the number of moles of hydrogen gas to the number of moles of ammonia gas. Use $PV = nRT$ to find V.

$$n = \frac{PV}{RT} = \frac{350\text{ kPa} \times 148\text{ L}}{8.314\frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 338\text{ K}} = 18.4\text{ mol}$$

Mole ratio: $\frac{3 \text{ mol } H_2}{2 \text{ mol } NH_3} = \frac{18.4}{x}$

$x = 12.3$ mol

$$V = \frac{nRT}{P} = \frac{12.3 \text{ mol} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 307 \text{ K}}{93.3 \text{ kPa}} = 336 \text{ L}$$

15. Use $n = m/M$ to find the number of moles of K. Use the mole ratio to find the number of moles of H_2. Use $PV = nRT$ to find the temperature of H_2.

$$n = \frac{m}{M} = \frac{3.55 \text{ g}}{39.10 \text{ g / mol}} = 0.0908 \text{ mol}$$

Mole ratio: $\frac{2 \text{ mol K}}{1 \text{ mol } H_2} = \frac{0.0908 \text{ mol}}{x}$

$x = 0.0454$ mol

$$T = \frac{PV}{nR} = \frac{117 \text{ kPa} \times 0.448 \text{ L}}{0.0454 \text{ mol} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}}} = 139 \text{ K}$$

16. Use $PV = nRT$ to find the number of moles of H_2. Use the mole ratio to find the number of moles of Al used. Use $n = m/M$ to find the mass of Al.

$$n = \frac{PV}{RT} = \frac{103 \text{ kPa} \times 1.50 \text{ L}}{294 \text{ K} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}}} = 0.0632 \text{ mol } H_2$$

Mole ratio: $\frac{3 \text{ mol } H_2}{2 \text{ mol Al}} = \frac{0.0632 \text{ mol } H_2}{x \text{ mol Al}}$

$x = 0.0421$ mol of Al

$m = n{\cdot}M = 0.0421 \text{ mol} \times 26.98 \text{ g/mol} = 1.14 \text{ g}$

17. First find the number of moles of both reactants. Use $n = m/M$ to find the number of moles of FeS. Use $PV = nRT$ to find the number of moles of O_2. Use the mole ratio to determine the limiting reactant. Then use the mole ratio to find the number of moles of Fe_2O_3. Use $n = m/M$ to find the mass of Fe_2O_3.

Moles FeS_2: $n = \frac{m}{M} = \frac{25.2 \text{ g}}{119.99 \text{ g / mol}} = 0.210 \text{ mol}$

Moles O_2: $n \frac{PV}{RT} = \frac{100 \text{ kPa} \times 5.50 \text{ L}}{293 \text{ K} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}}} = 0.226 \text{ mol}$

Mole ratio: $\frac{4 \text{ mol } FeS_2}{11 \text{ mol } O_2} = \frac{0.210 \text{ mol}}{x}$

$x = 0.578$ mol of O_2

Only 0.226 mol of O_2 are available, however. Since there is not enough O_2 available, oxygen gas is the limiting reactant.

Mole ratio: $\frac{11 \text{ mol } O_2}{2 \text{ mol } Fe_2O_3} = \frac{0.226 \text{ mol}}{x}$

$x = 0.0411$ mol

$m = n \times M = 0.0411 \text{ mol} \times 159.70 \text{ g/mol} = 6.56 \text{ g}$

18. Use $n = m/M$ to find the number of moles of N_2 and H_2. Use the mole ratio to find the limiting reactant. Use the mole ratio to find the number of moles of NH_3. Use $PV = nRT$ to find the volume of NH_3.

Moles N_2: $n = \frac{m}{M} = \frac{60.0\ \text{g}}{17.04\ \text{g / mol}} = 3.52\ \text{mol}$

Moles H_2: $n = \frac{m}{M} = \frac{9.00\ \text{g}}{2.02\ \text{g / mol}} = 4.46\ \text{mol}$

Mole ratio: $\frac{1\ \text{mol}\ N_2}{3\ \text{mol}\ H_2} = \frac{3.52\ \text{mol}}{x}$

$x = 10.6$ mol of H_2

There is not enough H_2 available, so hydrogen gas is the limiting reactant.

Mole ratio: $\frac{3\ \text{mol}\ H_2}{2\ \text{mol}\ NH_3} = \frac{4.46\ \text{mol}}{x}$

x = 2.97 mol of NH_3

$$V = \frac{nRT}{P} = \frac{2.97\ \text{mol} \times 8.314\ \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 273\ \text{K}}{101.3\ \text{kPa}} = 66.5\ \text{L}$$ or 66.7 L

19.

$n = \frac{m}{M} = \frac{20\ \text{g}}{26.98\ \text{g/mol}} = 0.74\ \text{mol}$

$n = cV = 4.0\ \text{mol/L} \times 0.700\ \text{L} = 2.8\ \text{mol}$

Mole ratio: $\frac{2\ \text{mol Al}}{6\ \text{mol HCl}} = \frac{0.74\ \text{mol}}{x}$

$x = 2.2$ mol of HCl

2.8 mol of HCl is available, so HCl is in excess. Aluminum is the limiting reactant.

Mole ratio: $\frac{2\ \text{mol Al}}{3\ \text{mol}\ H_2} = \frac{0.74\ \text{mol}}{x}$

$x = 1.1$ mol of H_2

$$V = \frac{nRT}{P} = \frac{1.1\ \text{mol} \times 8.314\ \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 300\ \text{K}}{107\ \text{kPa}} = 26\ \text{L}$$